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Some facts about the Torne and Kalix River Basins

A contribution to the NEWBALTIC II workshop in Abisko

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An overview

The Torne and Kalix rivers rise in the uppermost north west part of Sweden and their basins are situated between approximately 65°50N and 69°N as shown in Figure 1. The size basin of the two river basins is about 58 000 km^2 of which 14 500 km^2 (25%) is situated in Finland and 350 km^2 (0.6%) in Norway. The remaining, 43 150km^2, makes up 9.7% of the area of Sweden. Data presented in this paper originate from Swedish measurements. Finnish data of snow and evaporation from the east of the Torne River basin can be find in the Finnish Hydrological Yearbook (1994), which also includes some statistics for the period 1961-90.

The density of population is very low, about three people per square kilometre. People are mostly living in the river valleys near the coast, the towns of Haparanda, Torneo and Kalix, or in ore-mining centres like Kiruna.

Most of the basin can be characterised as a flat forest and mire area. The mountains in the north west part compose only 7-8 % of the total drainage basin. The runoff regime is thus characterised by a flow maximum produced by the snowmelt in the forest and swamp region. The mountains are very old. They were formed during the paleozoic era 300 000 000 years ago. As can be seen in Figure 3 at least 1/3 of the basin area is situated below 200masl and also about 1/3 above the 500m elevation line. Topography is further described in Figure 3.

As can be seen from Table 1, the Torne River is number two and the Kalix River number 10 in drainage area order of the Swedish rivers. Due to dominating south-west winds and orographic effects, the Abisko region has a proportionately low precipitation. The specific runoff of the Torne River is thus lower then other Swedish rivers in this part of Sweden.

Table 1. The Torne and Kalix river basins related to the ten greatest Swedish river basins.

Basin	Drainage area (km^2)	Runoff (m^3/s)	Runoff (mm)	Spec. runoff (l/s*km2)
The Göta River	50 120	574	360	11.5
The Torne River	40 160	373	310	11
Ångermanälven	31 860	474	490	15.5
Dalälven	28 950	353	380	12.2
Umeälven	26 820	432	520	16
Indalsälven	26 710	437	530	17
The Lule River	25 240	494	610	19.8
Mälaren-Norrström	22 650	162	230	7.2
The Ljusnan River	19 830	228	360	11.5
The Kalix River	18 130	280	500	12.1

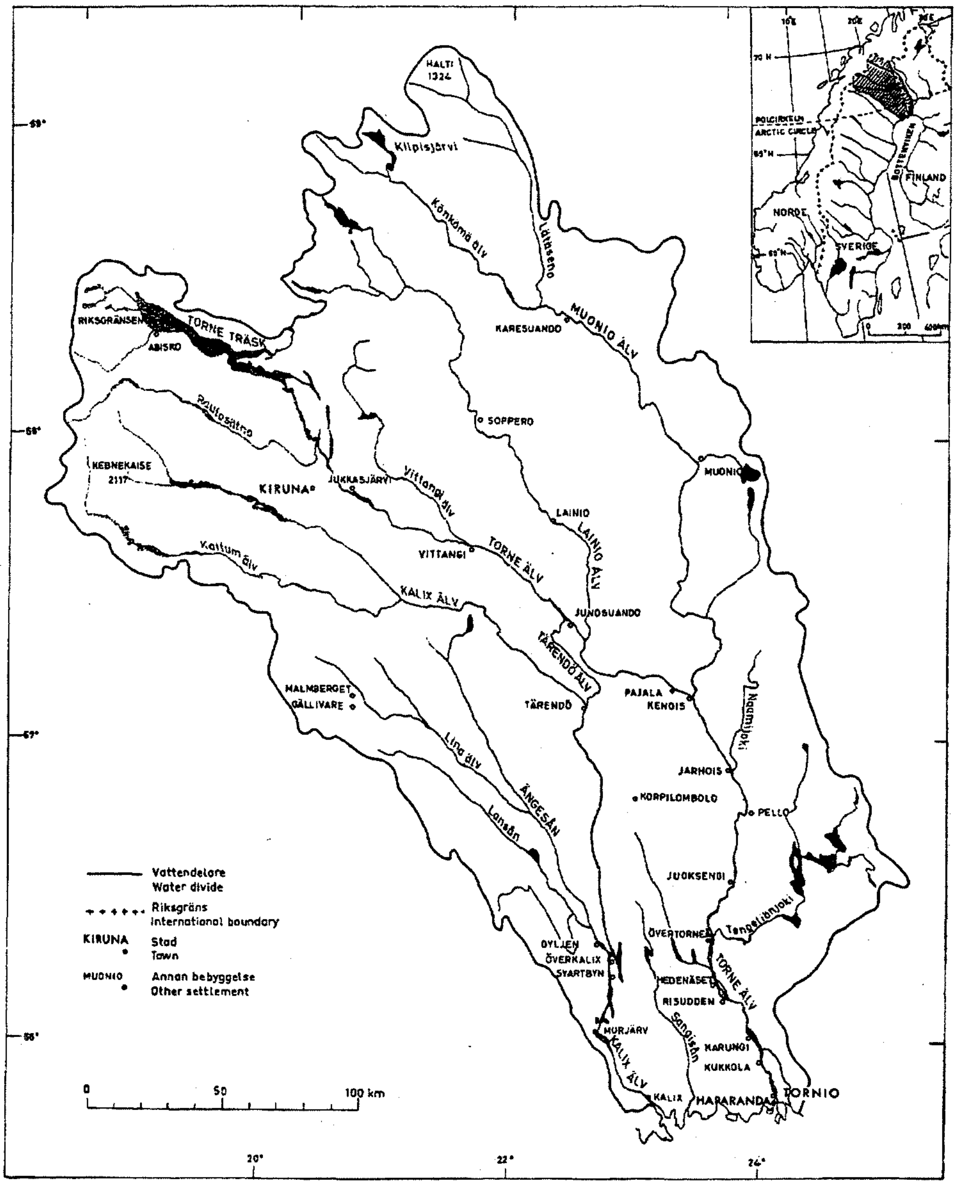


Figure 1. The Torne and Kalix rivers and their drainage basin. The map shows the main rivers and the largest tributaries. See also the water divides in Figure 4. (from Hjort 1971)

The Torne River and its tributary Muonio River form the border between Sweden and Finland. The basin area of the Torne River is more then 40 000km^2. The Torne River drains the largest mountain lake in Sweden, the Torneträsk. Its area is 322 km^2 and the depth is at most 168m. From Torneträsk to the Bothnian Bay the length of the river is 420 km. The largest tributaries are from north-west to south-east Rautosätno, Vittangi, Lainio, Muonio and Tengeliönjoki rivers.

The source of the Kalix River is the Kebnekaise mountains (2117 masl). The drainage area is some 18 000km^2. The most important tributaries are Kaitum, Linaälv-Ängesån. The length from source to mouth is about 450km.

Bifurcations are an important element in the drainage system. Through the bifurcation at Junosuando/Tärendö an average of 57% of the discharge is drawn off to the Kalix River. This means 83 m^3/s which correspondence to 22% of the total discharge at the mouth. Near the mouth at Karunki the tributary Liankanjoki in average draws off 23% of the discharge. This implies that the mean runoff at Tornio/Haparanda is somewhat less then at Karunki. If the bifurcation at Tärendö is taken into consideration the size of the Torne River Basin becomes about 31 300 km2 and the Kalix River Basin about 27 00 km2.

It is said that the kind of natural bifurcation at Junosuando/Tärendö is very rare. In fact there is only one more in the world, namely the Casiquare between the Orinoco and Rio Negro rivers in South America.

Both the Torne and Kalix Rivers should be considered as unregulated. There are some small dams but these do not affect the general runoff. Formerly they were used to regulate the water level for floating, that is, water born transport of timber.

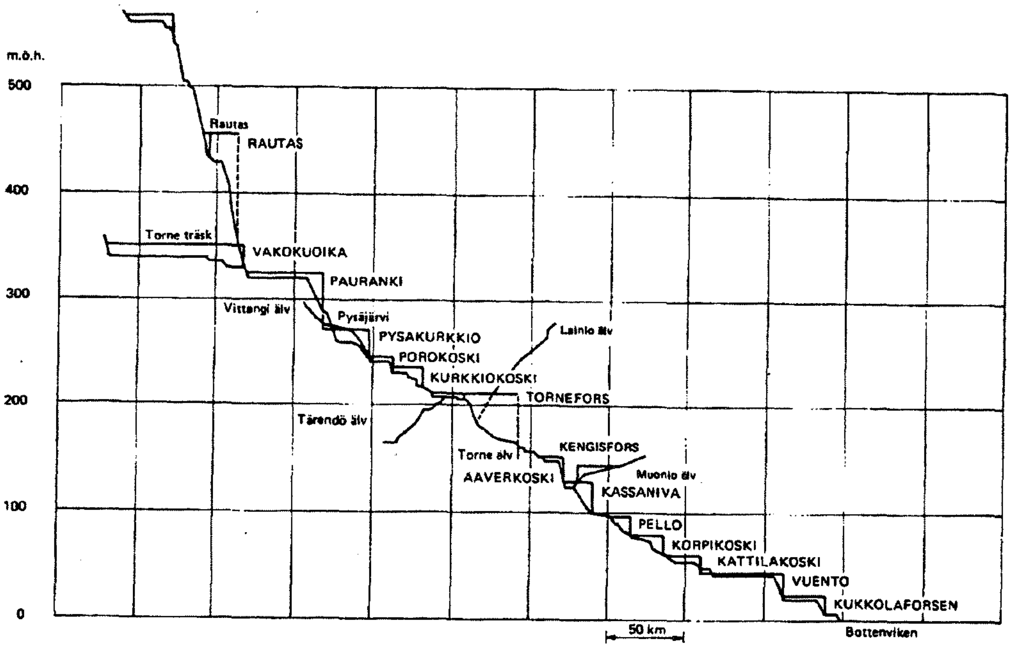


Figure 2. Proposed regulation 1979 of the Torne River.

In the 1970's there was a serious discussion whether the last unregulated four big rivers in Sweden should be developed for hydropower production or not. The Lule and Kalix rivers were two of the these rivers. The other two were Pite River and Vindelälven. In 1979 two governmental organisations (Statens Vattenfallsverk and Svenska Kraftverksföreningen) presented their official report which proposed the building of 10 to 15 hydropower stations in each of Torne and Kalix Rivers. This implied a fight between people for and against the hydropower development. As we now know the river environmentalists won this fight. The

development projects were never carried through and we can thus today use these river basins as good examples of unregulated areas in northern Scandinavia.

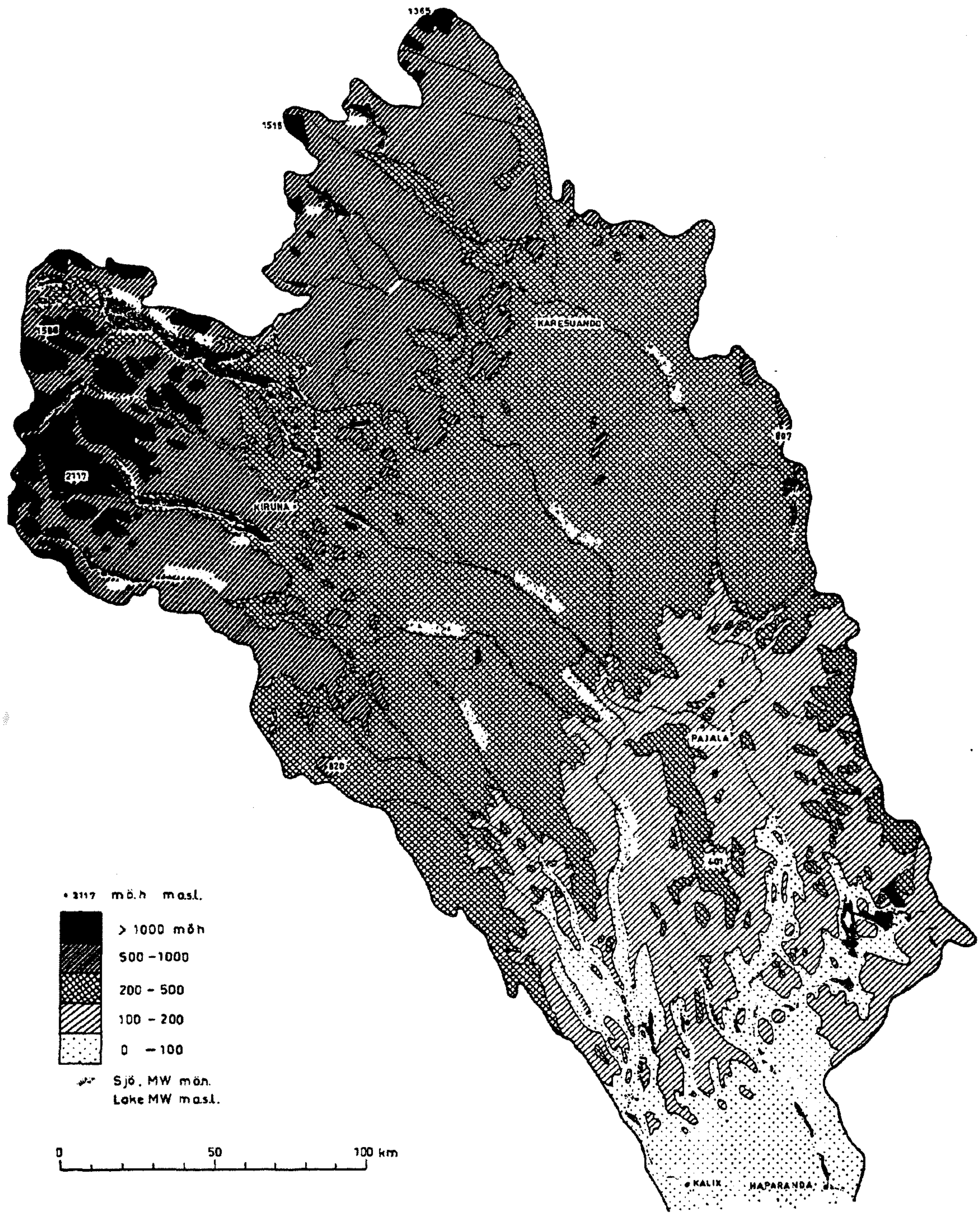
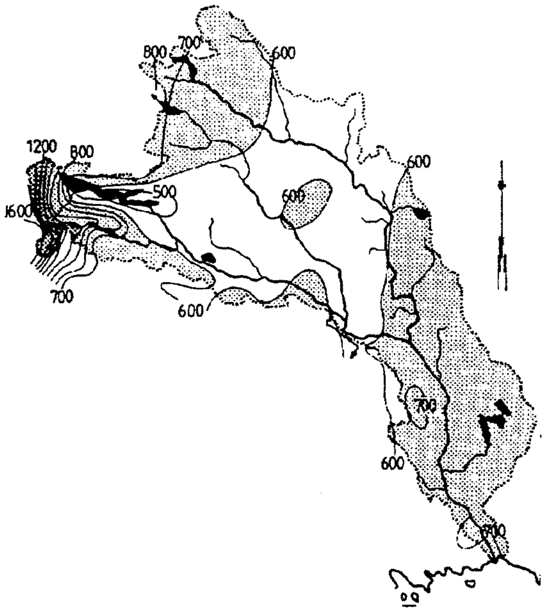


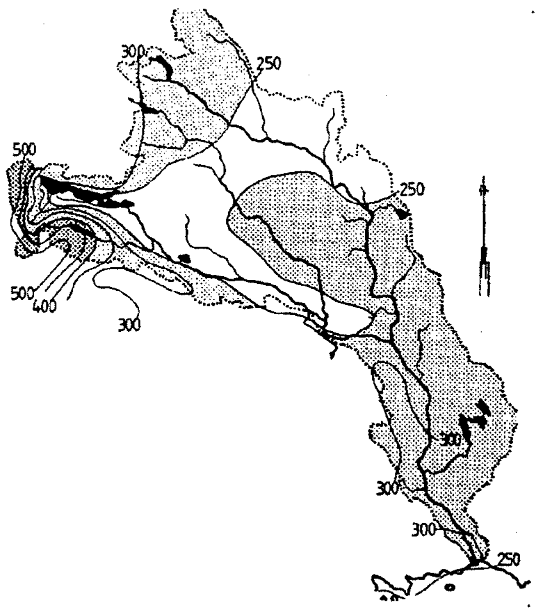
Figure 3. Topography of the river basins. Two main regions can be distinguished. In the north-west we have a region of high mountains with an altitude of more then 1000 m a s l. In the middle and south-east part there are low mountains, forests and mires. The area of high mountains is less then 10% of the total area and is mainly situated in the upper Kalix River basin. Typical for the basin is the very flat land in the lowermost part and the dales along the river. (from Hjort 1971)

• Precipitation station	— Major catchment boundary	Scale 1:1 900 000
○ Temperature station	— Subbasin boundary	
✱ Replacement station for precipitation		
□ Replacement station for temperature		
▼ Stream gauging station		
▽ Water level station		

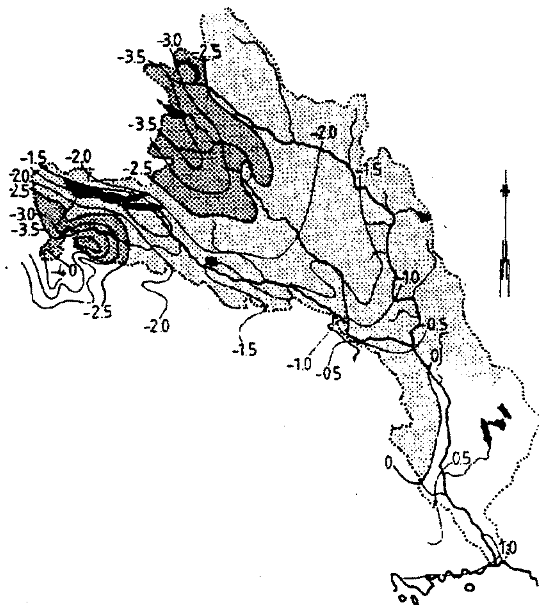
Figure 4. Torne and Kalix River basins with meteorological and stream gauging stations.



Annual total precipitation (mm) 1951-80.



Annual snow precipitation (mm water) 1941-70)



Annual mean temperature (°C) 1951-80.

Figure 5. Annual temperature and precipitation in the Torne River basin. (from Zachrisson 1989)

Near the coast the annual temperature is about +1°C. From here it decreases to -3.5°C in the north-west. Around the Torne Träsk it is somewhat milder. The precipitation, which is corrected for windlosses, is mostly around 600-700mm. But also here the area around the Torne Träsk is different as the precipitation is 500mm or less. The gradient towards the highest precipitation, 1600mm, in the mountains in north west is very steep. Days with snow cower increase from about 175 at the coast to 225 in the mountains. In Haparanda the snow has normally melted by the beginning of May.

The maps in Figure 5 are based on the stations in figure 4. See also the time series of temperature and precipitation from the three stations presented in Figure 7.

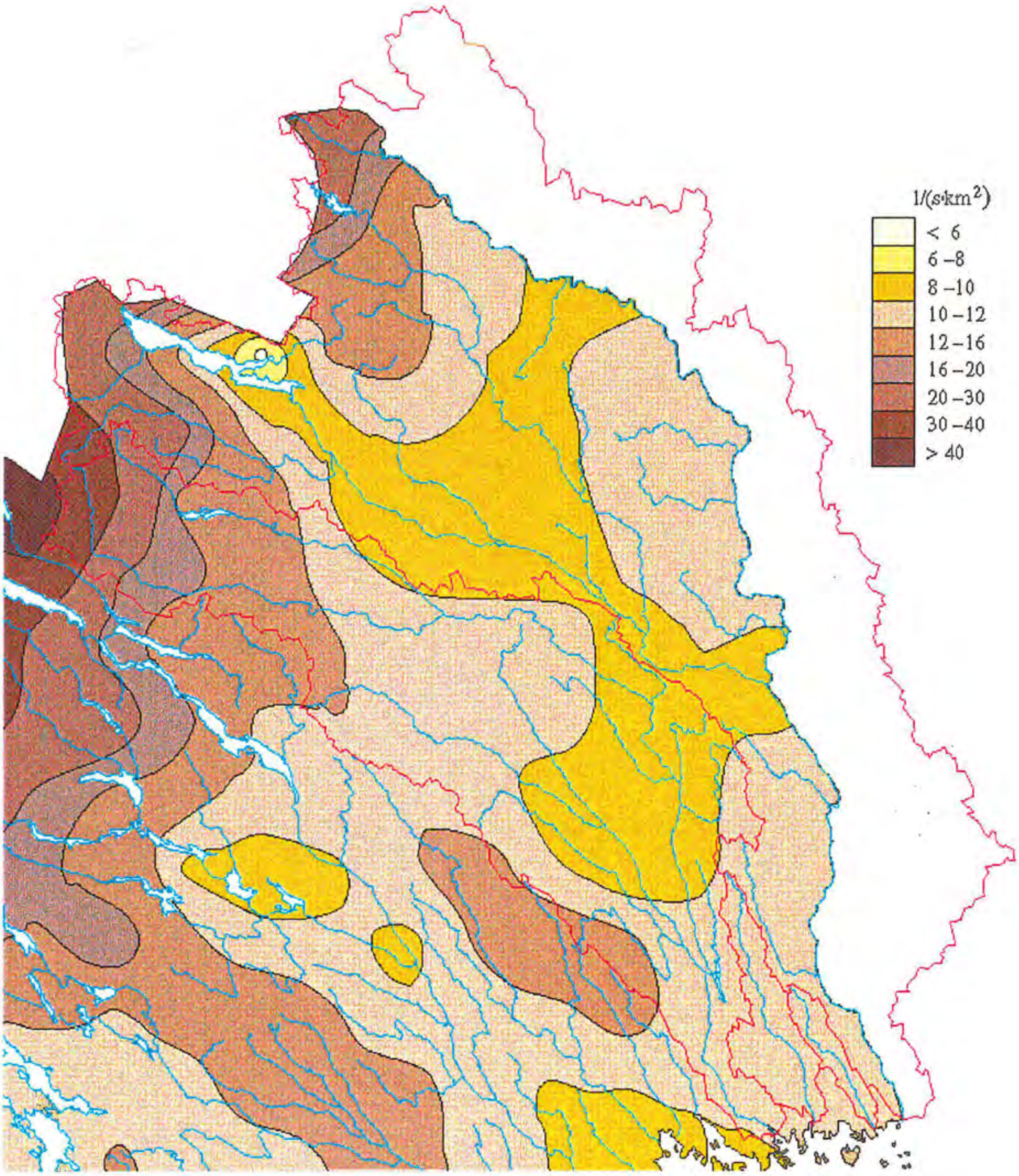


Figure 6. Specific runoff has been modelled for all Sweden in areas of 25x25km and the values are then connected with isolines. This Figure shows an area covering basins of the Torne and Kalix Rivers.

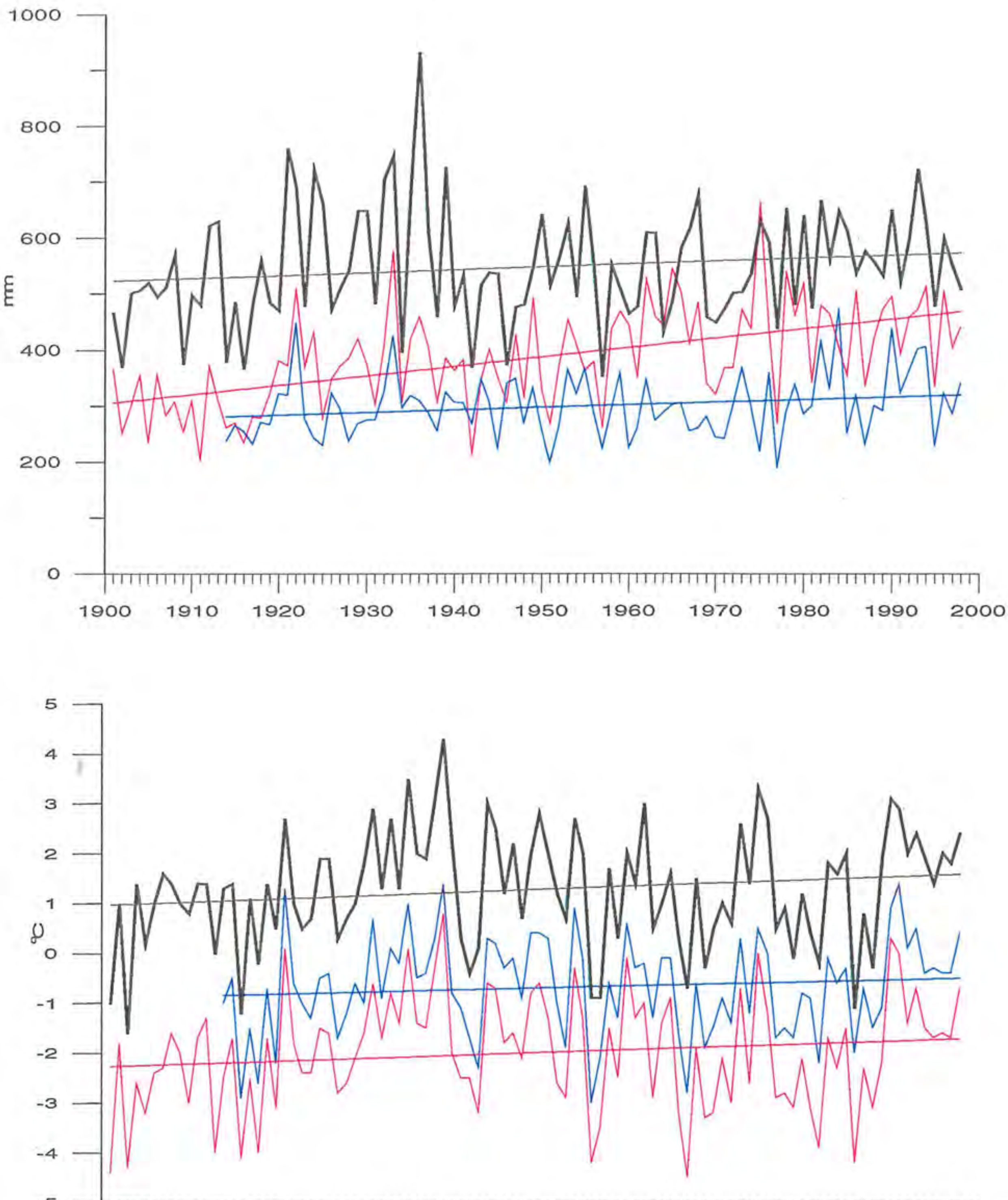


Figure 7. Annual means and linear fits for precipitation and temperature 1900-1997 in Haparanda (black), Karesuando (red) and Abisko (blue). Are there some trends in these data? Both temperature and precipitation show a small increase in time, but only the rise in precipitation at Karusuando seems to be significant.

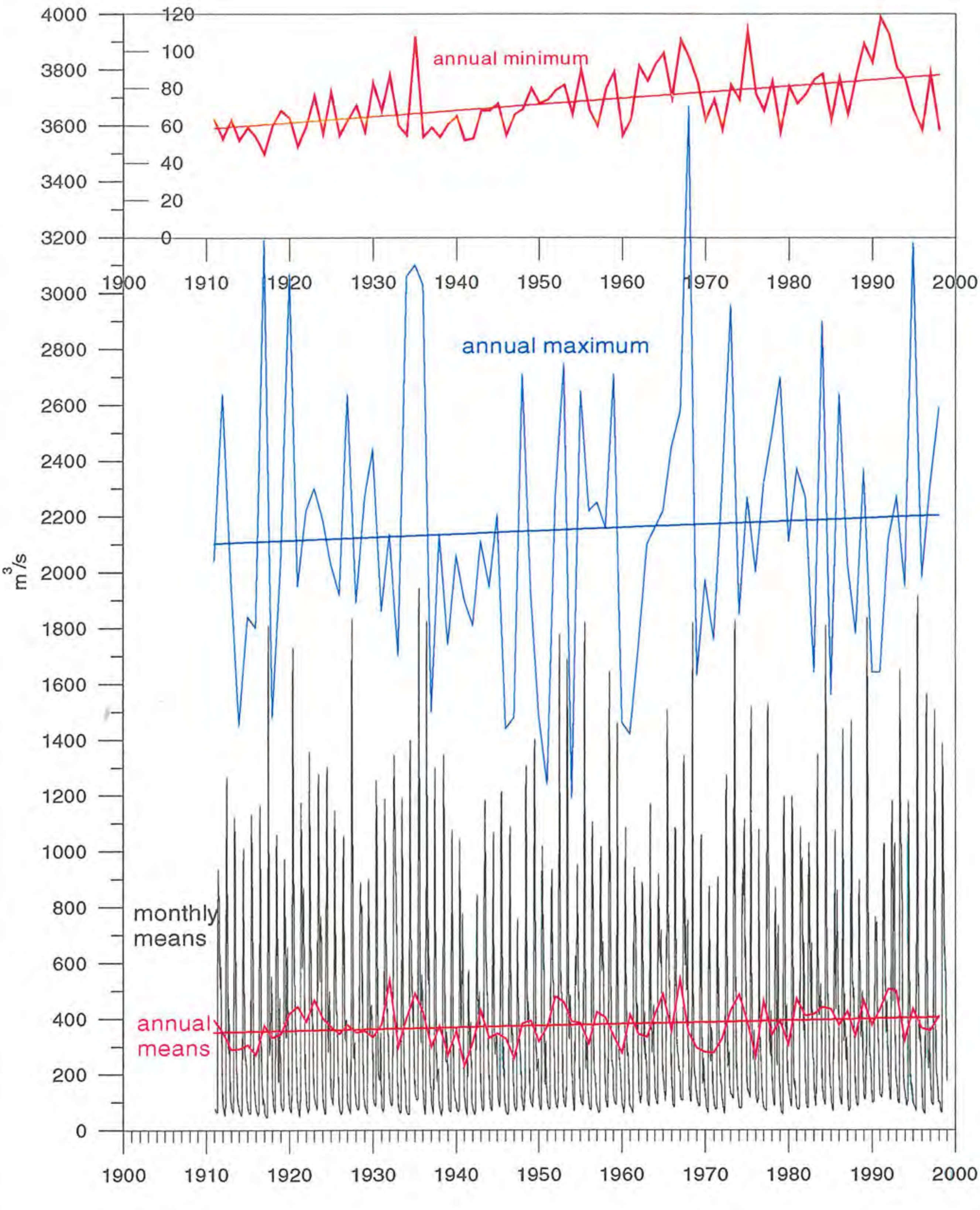


Figure 8. Runoff at the station Karunki (Kukkolankoski) 1911-1998, 25 km from the mouth in the Bothnian Bay. Like in the precipitation there may be a weak increasing tendency in the runoff and more in the maximum than in the minimum flows. Notice the ten times greater scale in the minimum values than for the other data. The rise had not been able to be detected with the same scale.

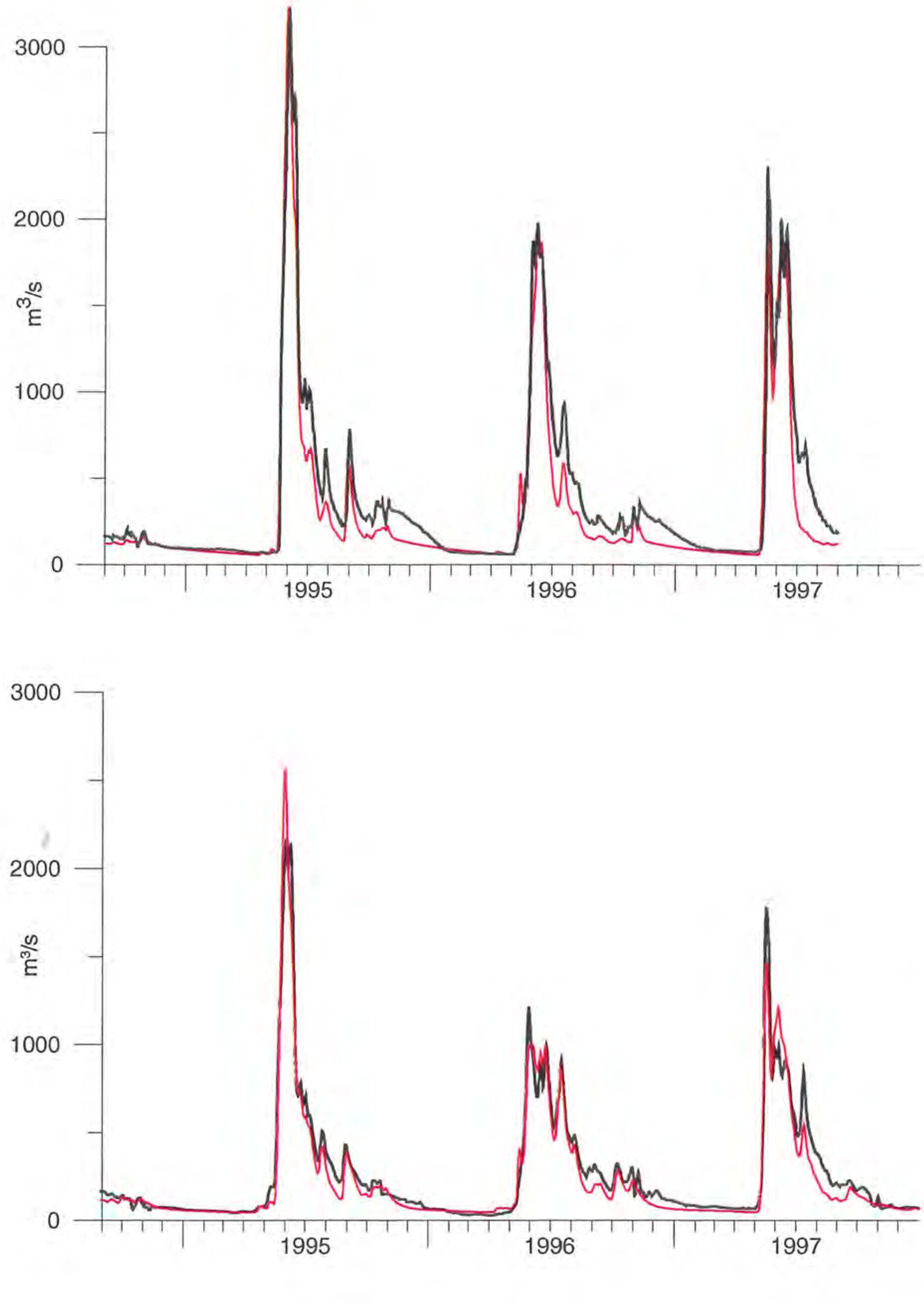


Figure 9. Runoff-modelling of the two rivers. The Torne (top) and Kalix (bottom) Rivers are both set up and modelled with the HBV-model. The HBV-model use 20 sub basins in each of the two main basins. This example from september 1994 to December 1997 shows that the modelling of the recession in the Torne River is inadequate and must be revised.

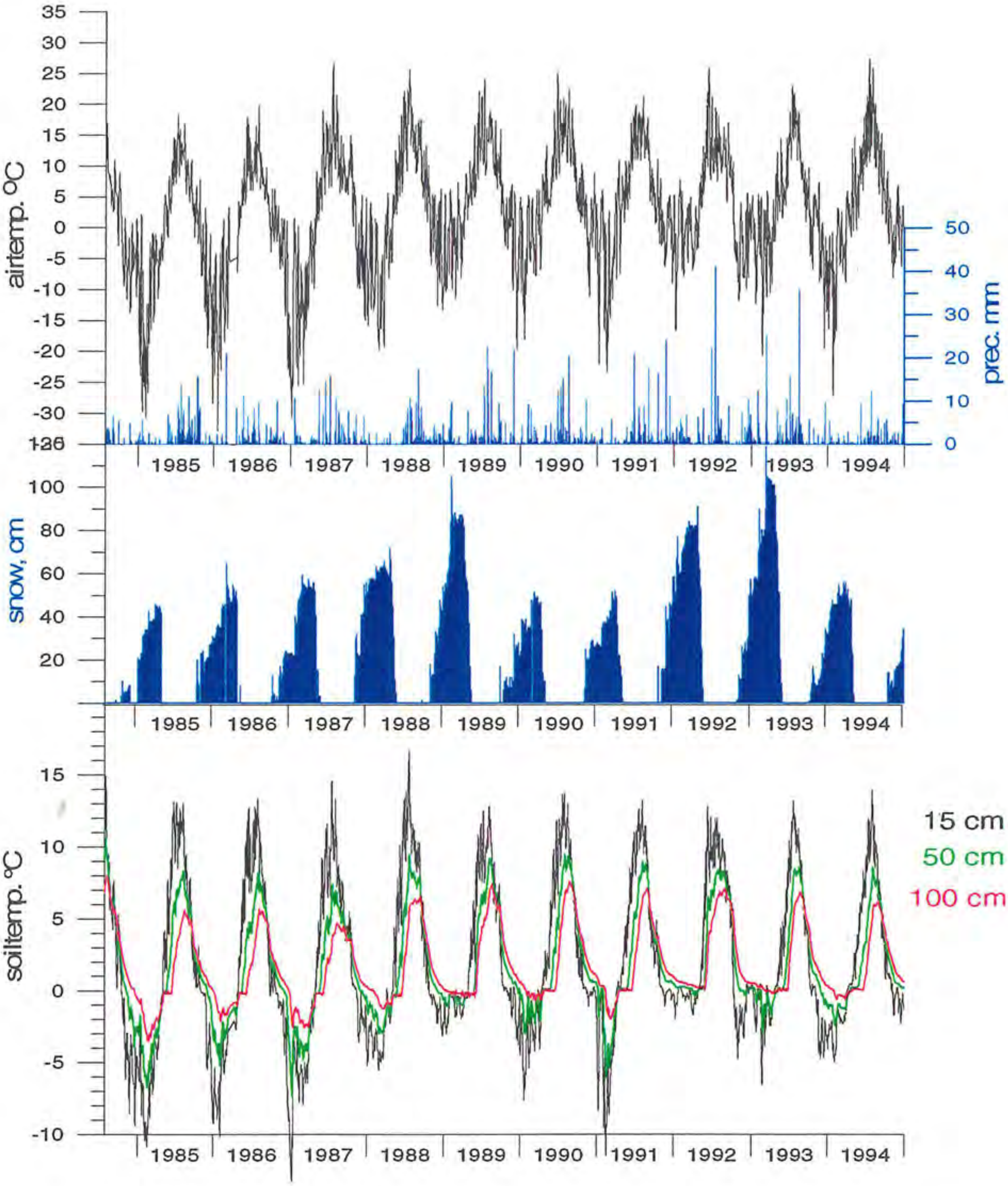


Figure 10. Daily data of air temperature, precipitation, snow depths and soil temperatures at three depths. Measurements in the Torneträsk area has been carried out since at least 1903, when the Abisko Scientific Research Station was established. Since 1935 it has been under the auspices of The Royal Swedish Academy of Sciences. Some of the long term data sets are presented on the internet, www.ans.kiruna.se, from where this data set, with exception of snow depth (Tjust 1999), is taken.

The sampling site is situated in the mountain birch region not far from the research station. It is obvious that a lot of snow implies a higher soil temperature during the wintertime. The importance of the air temperature at the beginning of snow covered period can be studied for instance by comparing the winters 1991/92 and 1992/93.

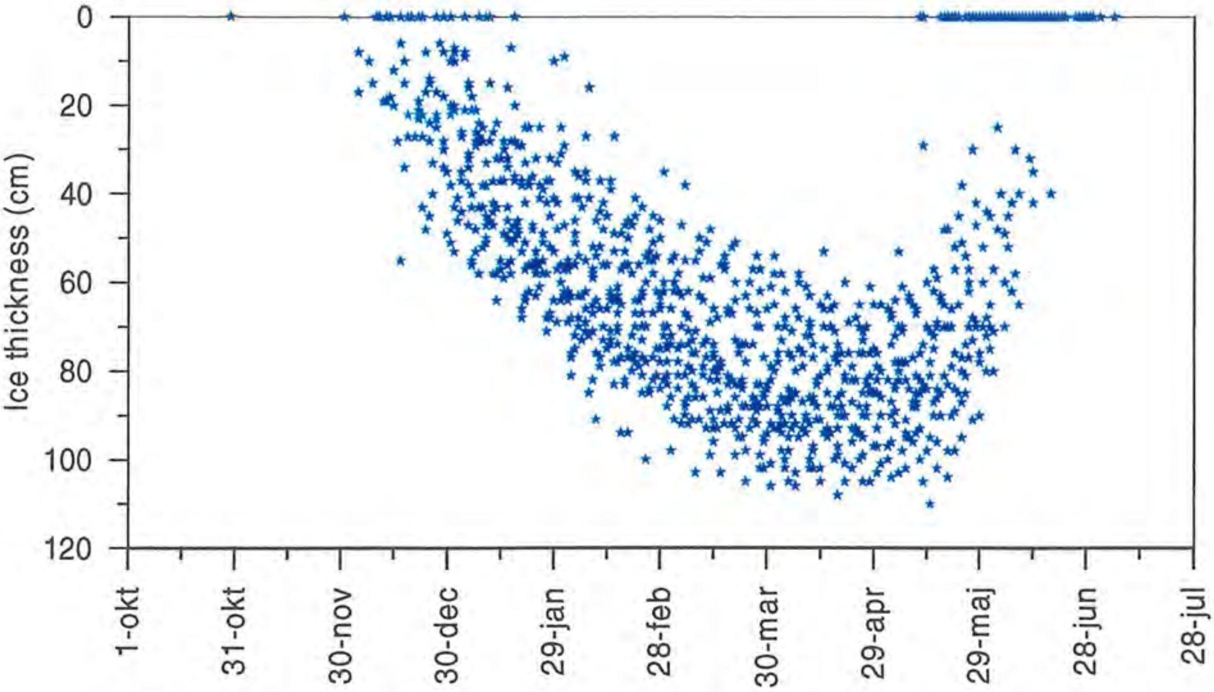


Figure 11. Ice thickness in lake Torne Träsk 1960-1990, all measurements about once a week. A great and deep lake situated in a valley between high mountains, mild winters and low precipitation make the ice situation of the lake Torne Träsk somewhat special. The ice is thus laid almost two month later then in other lakes in the basin. The ice thickness is considerable. In the winter 1965/66 the so far highest ice thickness, 110 cm, was registered. Depending on the low precipitation, i.e. not much snow, the ice consists normally mainly of clear ice with little snow ice (Eklund 1998).

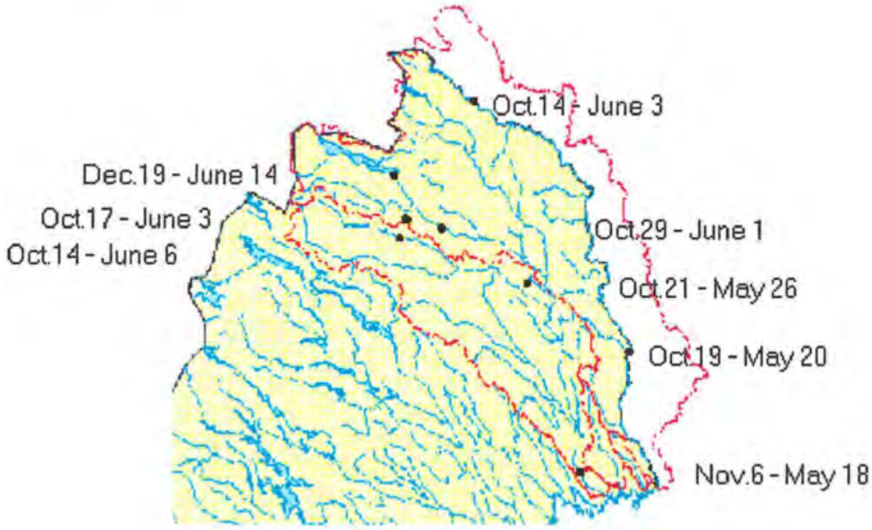


Figure 12. Due to the above mentioned climatological and geographical conditions the ice is laid almost two months later in lake Torne Träsk then in the adjacent lakes. Lake: •.

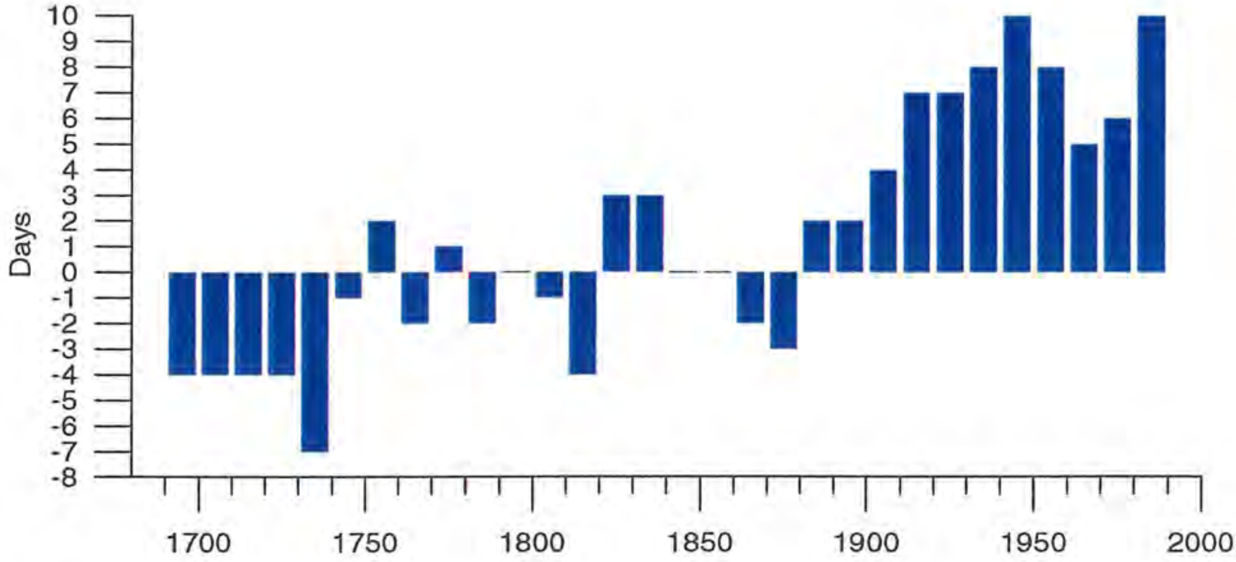


Figure 12. The day of ice break-up in the Torne River at Haparanda has been recorded since 1693. This Figure shows the 10-year mean deviation from the average 1801-1900. Positive values mean earlier ice break-up. Thus the present ice break-up occurs about 8 days earlier then before 1750. A milder climate in the spring is one reason for the change in time of ice break-up.

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